AGRICULTURAL APPLICATIONS

Satellite remote sensing data have been used operationally for agricultural applications for several years. For example, data from Landsat and the NOAA polar-orbiting instruments (especially AVHRR) have been used to determine crop types and conditions, and to measure crop acreage in all parts of the world. These data have also been widely used in models to produce crop yield forecasts. Diagnosis of different types of crop stress, including disease, insect infestations, and nutrient deficiencies is an example of the experimental use of remote sensing data.

Today's agricultural use of satellite remote sensing data is restricted by the limitations in the range and precision of measurements of the radiation reflected by the Earth's surface, inadequate frequency of data acquisition, the slow turnaround time between acquisition of the data to delivery to the user, the coarse spatial resolution of the data, and the excessive cost of much of the currently available satellite data.

One way that ESE will provide improved remote sensing data for agricultural applications is with unprecedented spectral range and resolution. MODIS, for instance, will measure radiation in 36 spectral bands. In contrast, only 4 to 7 bands are measured by the current satellite remote sensing instruments. This improvement will allow more precise definition of many plant properties.

MODIS will also represent improved temporal resolution over data from current remote sensing instruments, producing images that cover the globe every 2 days. By comparison, the widely used Landsat 5 satellite has a global repeat cycle of 16 days. Improved temporal resolution will allow better monitoring of crop development stages and yield prediction during the growing season. High-resolution remote sensing data, provided by other ESE instruments, has great applicability for monitoring crop conditions to optimize the application of seed, fertilizer, pesticides, and water.

Current and potential uses of satellite remote sensing data for agriculture are listed in the following table. In the Agriculture Applications Matrix, the rows correspond to specific applications, and the columns correspond to individual ESE instruments. The potential use of data from a given ESE instrument to a specific agricultural application is denoted by a check mark in the matrix.

Agricultural Applications Matrix

Application	MODIS	ASTER	Landsat 7	MISR	CERES	TMI	PR	EOS Models	SeaWiFS	SRTM	AMSR	AIRS/ AMSU/ MHS	ESSP VCL
1 Measuring Crop Acreage		✓	✓										
2 Classifying Crop and Vegetation Type	✓	✓	✓	✓					✓				✓
3 Estimating Crop Yields and Optimizing Fertilization	✓	✓	✓										
4 Determining Vegetation and Crop Health	✓	✓	✓	✓		✓			✓		✓		✓
5 Analyzing Pest Mitigation and Planning Pesticide Application		✓	✓										
6 Determining Range Readiness and Health/Maturity	✓	✓	✓						✓				
7 Monitoring Fallow Land		✓	✓										
8 Determining Soil Moisture and Drainage	✓	✓				✓	✓			✓	✓	✓	
9 Optimizing Irrigation--Aerial Distribution and Timing	✓	✓	✓	✓			✓	✓	✓			✓	
10 Mapping and Monitoring Wetlands	✓	✓	✓	✓			✓		✓	✓			
11 Monitoring Droughts and Floods	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓
12 Timing Harvest Before Destructive Weather Events	✓												
13 Mapping Soil, Nutrient, and Landscape Spatial Variability	✓	✓	✓										
14 Monitoring Soil Erosion	✓	✓	✓						✓				
15 Improving Climate Forecasts				✓	✓			✓					

ESE Instrument

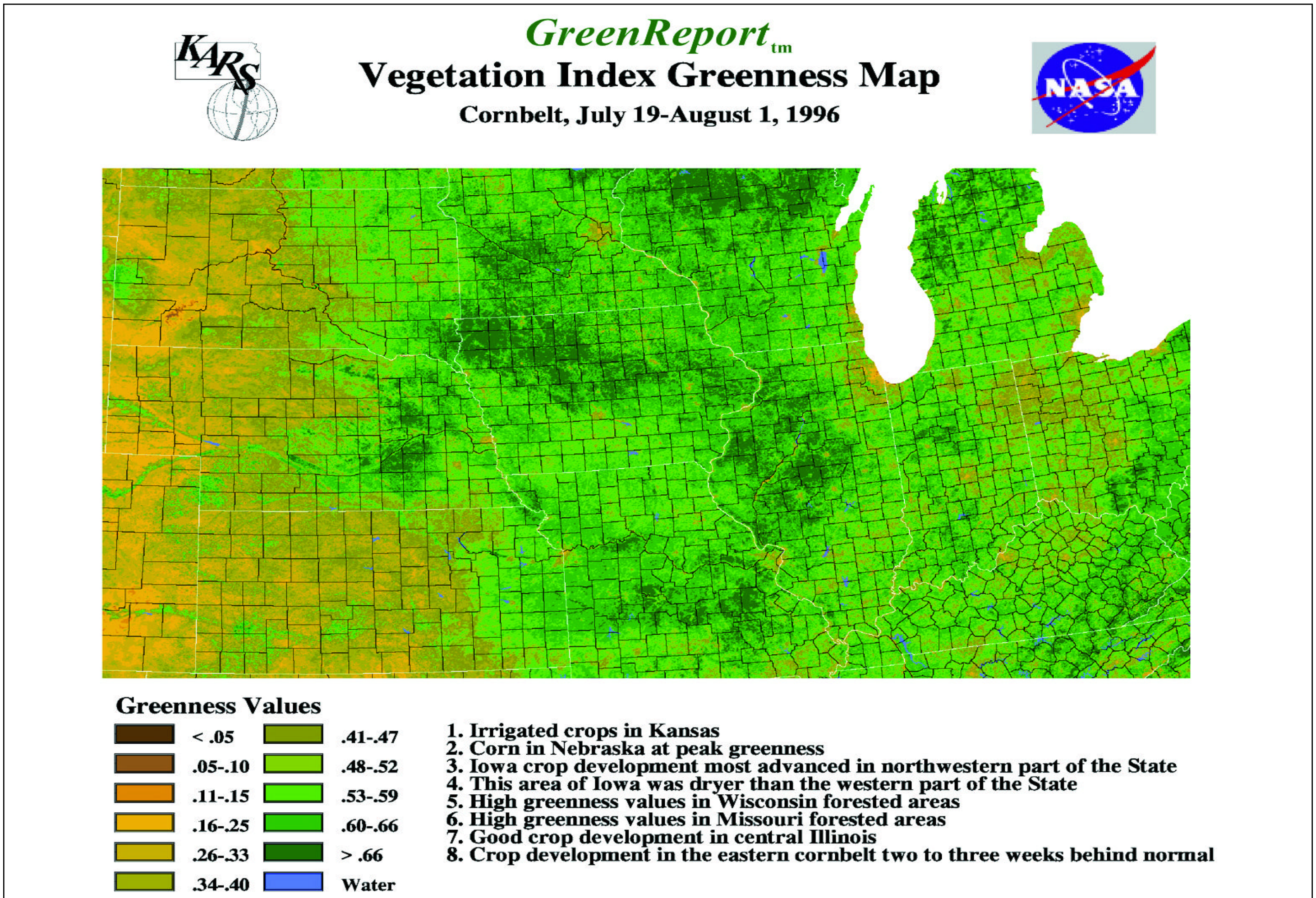
1 Measuring Crop Acreage

This time-tested remote sensing application for global and regional monitoring of agricultural land use is also valuable for estimating harvest and crop acreage more precisely and understanding the resource by crop type. Data from MODIS may be used for regional and global assessments.

2 Classifying Crop and Vegetation Type

Local and regional agricultural planning and management requires understanding the distribution of different crop types within a given region during the growing season. Satellites can distinguish crop types based on the unique reflectance spectra in the visible and near-infrared (VNIR) regions of the electromagnetic spectrum. Since the biochemistry and pigmentation of different crops varies, the reflectance spectrum for each crop is unique and can be mapped by instruments with high spectral resolution, like MODIS. MISR, too, can obtain the reflectance spectrum, which varies with different plant species. ASTER and Landsat 7 data feature high spatial resolutions, allowing researchers to distinguish local variations in crop parameters.

AGRICULTURAL APPLICATIONS



The University of Kansas Applied Remote Sensing Program uses satellite remote sensing data to produce the GreenReport, a weekly map set that illustrates crop/vegetation condition, progress, and change in the U.S. for commodity business, grain traders, seed buyers, range managers, and crop insurance providers. This example shows crops and vegetation in the Corn Belt during summer 1996. Areas that appear dark green contain abundant mature plants. Lighter green colors depict areas with lesser amounts of vegetation or vegetation in earlier stages of development. Yellow and brown areas indicate sparse vegetation.

3 Estimating Crop Yields and Optimizing Fertilization

The Normalized Difference Vegetation Index (NDVI), the ratio of near-infrared to red spectral components, has already proven extremely useful in accessing crop yields weeks before harvest. The United States Department of Agriculture (USDA) has used this method to estimate crop yields for several years. MODIS data will enable the USDA to produce more precise vegetation indices. MISR data will add to this knowledge by providing reflectance data that can be correlated to leaf condition, an indicator of plant health.

4 Determining Vegetation and Crop Health

Images from MODIS offer the potential to evaluate crop health through improved characterization of plant chlorophyll, photosynthesis, and biomass. Vegetation stress will be detectable before it becomes visible to the eye, and subtle regional variations in crop health will be distinguishable. This knowledge assists farmers with large fields in targeting fertilization strategies for maximum benefit. Landsat data are already valuable in these applications.

5 Analyzing Pest Mitigation and Planning Pesticide Application

Insect infestation, plant viruses, fungi, and bacteria are among the most challenging environmental hazards that farmers face. Successful mitigation depends on early detection and regional tracking. Because of its chlorophyll sensitivity and frequent global coverage, MODIS will aid in collecting data useful in early detection of plant damage / defoliation, as well as assessing regional variability. The high spatial resolution of Landsat and ASTER data will complement MODIS by aiding in planning precision pesticide application. Landsat data are already being used in the agricultural industry to detect and respond to damaged crops and farmland resulting from insect infestation and disease.

6 Determining Range Readiness and Health/Maturity

With adequate field validation, patterns of overgrazing are among the most detectable land features from space. The MODIS, ASTER, and Landsat 7 sensors will provide good spectral resolution and, when calibrated by field studies, will generate data that will aid in qualifying range and grassland health and maturity. This information will directly benefit farmers and ranchers by allowing them to optimize their animal load levels.

7 Monitoring Fallow Land

Fallow land can be considered an appreciating asset -- the value of which increases as the soil recovers. Understanding its condition leads to better trend forecasting in agricultural supply and demand. Fallow land can be mapped with data from ASTER and Landsat 7 sensors.

8 Determining Soil Moisture and Drainage

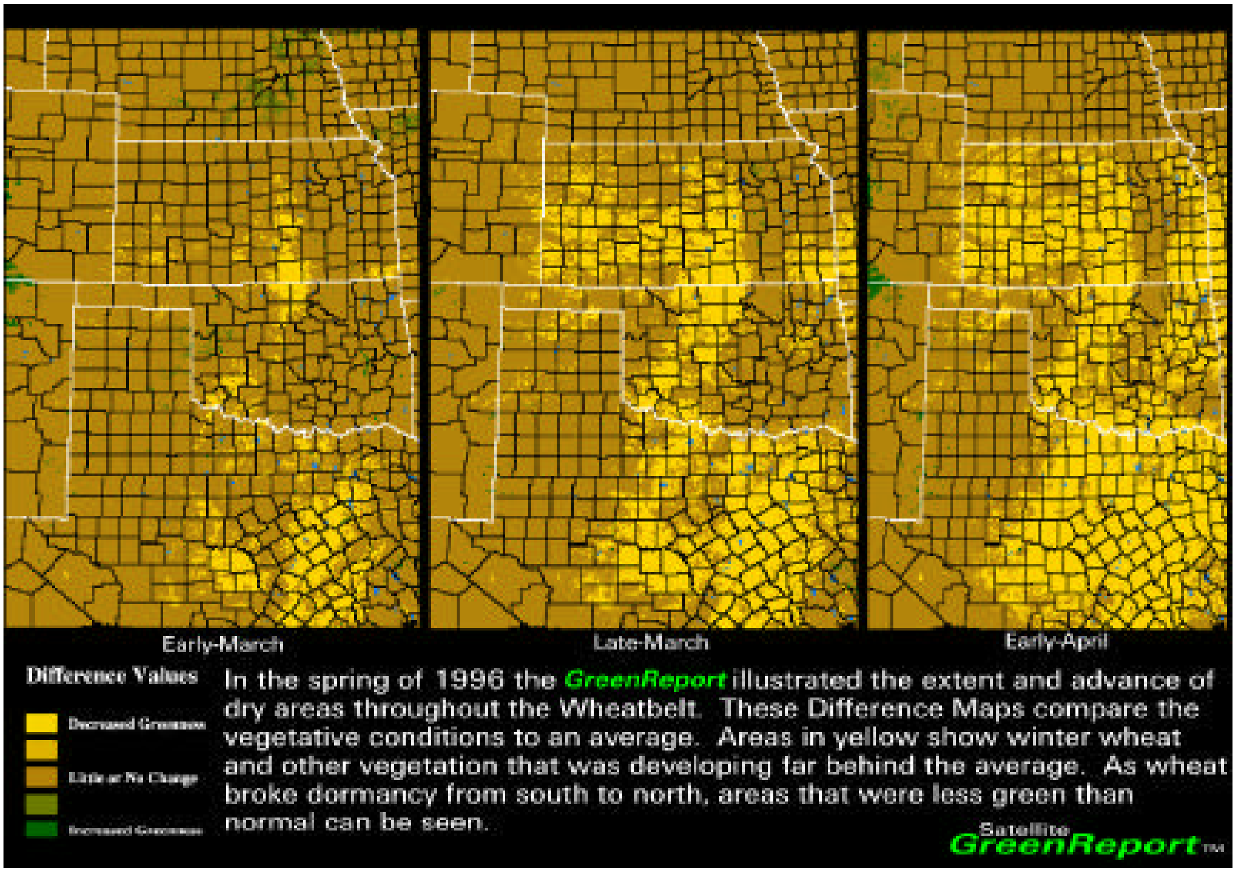
Direct estimates of soil moisture are being gathered by the TRMM Microwave Imager (TMI) and the Advanced Microwave Scanning Radiometer (AMSR) passive microwave instruments. Indirect assessments of moisture regimes will be provided by all the visible / near-infrared instruments. The Clouds and the Earth’s Radiant Energy System (CERES) and MODIS instruments will also yield daily solar radiation, cloud cover, and surface temperature estimates, which will enable improved estimates of surface evaporation and plant evapotranspiration. In addition to direct monitoring, improved meteorological forecasts derived from ESE-related climate modeling activities will assist in planning cost-effective irrigation strategies.

9 Optimizing Irrigation—Aerial Distribution and Timing

Estimating crop residue cover is necessary for proper soil conservation and tillage management. Use of remote sensing data for this application is currently in the experimental stage, but there is potential for use of hyperspectral data from MODIS for regional application.

10 Mapping and Monitoring Wetlands

Soil moisture data provided by AMSR and TMI instruments will allow the assessment of the state and variability of wetlands. Also, the multi-angle reflectance measurements of the MISR instrument will aid in mapping regions of shallow water cover, which might be missed by conventional visible / near-infrared sensors.



The University of Kansas Applied Remote Sensing Program provides a weekly set of three Greenness Difference Maps for counties in the Great Plains States and the continental U.S. The map sets compare the current crop/vegetation conditions to conditions in the previous week and year to an average. This example illustrates the poor winter wheat condition in spring 1996 as compared to the average. Yields were about 50 percent of the average.

11 Monitoring Droughts and Floods

Predicting the climatic conditions leading to seasonal drought is one of the chief goals of ESE climate forecasts. Timely drought and flood monitoring will improve damage assessments and enhance mitigation strategies. For drought monitoring, passive microwave instruments, like AMSR and TMI, will be able to quantify progressive changes in soil moisture through time. Also, MODIS will provide frequent data on vegetation condition, which can be indicative of drought conditions.

Flood monitoring requires the relatively high spatial resolution instrument data such as that from ASTER and Landsat 7, combined with frequent coverage of the MODIS sensor. The passive microwave instruments can also provide data on rain rates and soil moisture. These data will be used in weather models to provide improved short-term precipitation forecasts that will aid in predicting floods.

12 Timing Harvest Before Destructive Weather Events

Severe fall storms during fall harvest activities affects the livelihoods of farmers in the Gulf and Atlantic states. For instance, just a few days advance notice of an impending storm could have allowed sufficient time for early harvest before the tremendous damage caused by Hurricane Camille to Texas and Louisiana farmlands on September 13, 1961. On a longer time scale, improved seasonal hurricane forecasts could allow farmers to insure crops in advance or plant crops amenable to early harvest.

13 Mapping Soil, Nutrient, and Landscape Spatial Variability

Understanding soil conditions across an individual farm can influence fertilization strategies, thus maximize harvests. MODIS, ASTER, and Landsat 7 data can help make assessments by detecting subtle shifts in soil spectra related to the spectral signatures of the minerals and organic matter present.

14 Monitoring Soil Erosion

The SeaWiFS instrument provides data on the sediment content of agricultural runoff, which will enable more reliable soil erosion estimates in estuaries, bays, and lakes. MODIS also features excellent spectral resolution in the near-infrared, allowing researchers to determine sediment concentrations in these regions. The high spatial resolution of ASTER and Landsat 7 will allow researchers to monitor sediment concentration in smaller rivers and lakes.

In addition, stereo photogrammetry, using pairs of ASTER scenes will yield high-resolution topography, equal to or better in resolution than current maps. This topographic data will allow more precise prediction of river hydrology, runoff, and erosion.

15 Improving Climate Forecasts

Just as improved weather forecasts will help farmers decide on the timing of harvests and other critical matters, ESE-provided climate forecast models will contribute to improved seasonal farming strategies. Advanced knowledge of the characteristics of a growing season will influence crop selection and the timing for planting and harvesting. The ESE climate models will integrate the output from many of the ESE instruments and be supported by CERES, AMSR, and TMI data.